CIAIAC

Comisión de Investigación de Accidentes e Incidentes de Aviación Civil

TECHNICAL REPORT

IN-069/2002

Incident involving BOEING B-747-300 aircraft, registration TF-ATH, at Madrid-Barajas Airport on 14 September 2002

MINISTERIO
DE FOMENTO

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SUBSECRETARÍA

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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WARNING

This Report is a technical document which reflects the point of view of the Air Accidents and Incidents Investigation Commission (CIAIAC) regarding the circumstances in which the event being investigated happened, with the relevant causes and consequences.

In accordance with Annex 13 to the International Civil Aviation Convention and with Royal Decree 389/1998, of 13th March, which regulates the investigation of civil aviation accidents and incidents, the investigation is of an exclusively technical nature, without having been targeted at the declaration of blame or liability, or limits of personal or financial rights or liabilities. The investigation has been carried out without having necessarily performed legal evidence procedures and with no other basic aim than preventing future accidents. The results of the investigation do not determine or prejudge any disciplinary proceedings that, concerning the event, may be brought by the "Ley de Navegación Aérea" (Air Navigation Law).

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Abbreviations

00 ºC	Degrees centigrade
ACP	Electrical pump
ADP	Air driven pump
APU	Auxiliary Power Unit
ATC	Air Traffic Control
CM-1	Pilot in command
CM-2	Copilot
CM-3	Fligth engineer or Flight Technical Operator
CVR	Cockpit Voice Recorder
EDP	Engine driven pump
EGT	Exhaust Gas Temperature
FDR	Flight Data Recorder
FMS	Flight Management System
ft	Feet
g	Acceleration of gravity
GMC	Ground Movement Control at Barajas Airport
h: min: seg	Hours, minutes, seconds
hPa	Hectopascal
IAS	Indicated airspeed
JAR	Joint Airworthiness Requirements
Kt	Knots
lb	Pound
m	Meter
MEL	Master Equipment List
METAR	Meteorological Report
MHz	Megaherzts
N/A	Not affected
OTV	Flight Engineer or Flight Technical Operator
P/N	Part Number
PSI	Pounds per square inch
S/N	Serial number
TCP	Passenger Cabin Attendant
TWR	Control Tower
U T C	Universal Time Coordinated

1.- FACTUAL INFORMATION

1.1.- History of the flight

The flight crew of the aircraft TF-ATH, initially scheduled to depart to Mexico D.F. on 14 September 2002, at 12:30 h local time, was composed of the pilot in command (CM-1), the first officer (CM-2), the flight engineer (CM-3), a relief first officer and a relief flight engineer. As the flight had a long delay, the CM-1 and CM-2 boarded the aircraft at around 16:50 h local time.

The takeoff weight for the flight was calculated to be 364291 kg, and there were 18 crew and 355 passengers. The Maximum Take Off Weight of the aircraft is 374850 kg.

The B-747-300 was parked besides finger T-1 at Madrid-Barajas Airport. The flight, had suffered a delay of more than 4 h because of late arrival and maintenance issues. The previous flight of the aircraft was La Habana-Madrid, in which the indicator of Exhaust Gas Temperature (EGT) of engine number 3 was reported as inoperative. Additionally, it was reported after that flight that there was a difference between fuel loaded, as measured by stick, and fuel indicated on the cockpit for main fuel tank number 2.

The number 3 EGT indicator was changed in Madrid. As during the cruise flight from La Habana it seemed that the difference in fuel indication had corrected itself, the aircraft was refueled in Madrid measuring the quantity with stick and there was no difference with the indication in the cockpit. This item was therefore kept in observation.

Upon arrival to the aircraft, the flight crew observed that there was an important spillage of fuel from the starboard wing tanks, which were being refueled. The relief flight engineer was already there and was talking to the ground crew in an attempt to stop the fuel leaking. Fire fighting crew were also in the area applying water to the ground to prevent any fire hazard.

The crew boarded the aircraft and started preparing the flight in the cockpit and the fuel leakage continued for some time, even while the passengers were embarking the aircraft through finger T-1. The chief stewardess of the passenger cabin crew entered the cockpit to inform the commander that some passengers were observing the fuel leakage through the cabin windows.

Finally, the leakage stopped. The commander asked the relief flight engineer to take a seat in the passenger cabin, to allow a passenger who had asked for the possibility to seat in the cockpit during the takeoff to occupy one of the five seats located in the cockpit. The other four seats of the cockpit were occupied by CM-1, CM-2, CM-3 and the relief first officer.

The crew, after performing the pre-start checks, asked Ground ATC clearance for pushback at 17:38:45 h local time (15:38:45 h UTC). The ATC controller provided the clearance five seconds later, which was acknowledged by the crew of TF-ATH at 15:38:54 UTC, and later on a tow vehicle of the same operator started the pushback. The aircraft was energized by the Auxiliary Power Unit (APU) all the time.

During the pushback, and in addition to the tug driver, there was a technician on the ground assisting the crew through a microphone and headphones plugged to the aircraft.

According to the statement provided by this person, the flight crew asked whether it was clear to start the engines during the pushback. The ground support person advised to wait a little bit in order to allow some vehicles to cross the area. Afterwards, he informed the flight crew that is was clear and engines could be started.

The flight crew told him that the sequence would be engines one, two, three and four. The ground person provided his agreement and informed that the (number) one was clear and, then, that the (number) one was rotating.

Then the sequence continued with engine two ("rotating the two"), engine three ("rotating the three") and, at that moment, when the aircraft had almost crossed taxiway B2, the aircraft braked abruptly, and the tow bar hit the nose gear leg. The tug driver asked for the reason of that sudden braking, and the ground person asked the crew about that action. The crew answered that they had understood that the ground person had requested "Parking brake". That person replied that he had said "Rotating engine three". The crew apologized and argued that they had misunderstood the request because they were talking to the tower.

The ground person said that there was no problem and that, at that moment he was positively requesting parking brake, because the aircraft had finished the pushback. This request was repeated a couple of times. The crew answered confirming that the parking brakes were applied. The tow vehicle was then disconnected from the aircraft and went off.

According to the statement provided by some cabin attendants, as the passengers boarded the aircraft some of them saw fuel leaking and the fire fighters acting in the area. One of the passengers noticed through the window that there was a technician walking over the wing. The stewardess that was close to that passenger tried to calm him down, even though she did not know what was the maintenance problem. The closure of the doors was delayed for some time. These facts, in addition to the 5 hours of accumulated delay with respect to the originally scheduled time of departure, probably created to some extent what was reported as a subjective stress and anxiety in some of the occupants of the aircraft.

Once the doors were closed and the ramps armed, a welcome address and routine safety instructions were provided to the passengers through the public address system. As the aircraft was being pushed back, the normal safety demonstrations to the passengers continued. At some point, some passengers in the area of door 5R saw again fuel leaking from the RH wing tip. A few moments later, several passengers were observed to be standing. Some of them had taken their hand luggage, stating that they wanted to disembark. One of the passengers, which reportedly had symptoms of some previous alcohol consumption, was the most active person that was refusing to fly. Some passengers stated that they thought the aircraft was not safe to start the flight.

The chief cabin attendant went to the rear part of the aircraft and observed the fuel leakage. According to her experience, she thought that the leakage was similar to that noticed other times through the RH wing venting system.

She then went to the cockpit and informed the pilot in command about the mood of the passengers and the fuel leakage, and asked for instructions on how to proceed.

At that time, according to the statements provided by the flight crew, they were starting engine 3. The engine started in a normal mode, but when the EGT indication started to descent, it showed oscillations in both the needle and the digital indication. Finally the needle fell to zero and the flag appeared on the indicator, rendering it inoperative.

The pilot in command asked the CM-3 to check the impact of the inoperative indication on the Minimum Equipment List (MEL) of the aircraft. He told the chief cabin attendant to address the passengers and to try to calm them.

The chief cabin attendant used the public address system to talk to the passengers, informing that there was no problem on the aircraft and trying to get them all seated. However, some passengers were still standing and complaining. Some passengers among the most active in complains were sent to the forward part of the aircraft in an attempt of the cabin crew to avoid their negative influence on the mood of other passengers.

In the mean time, after the flight crew confirmed that the parking brake was applied, they asked the ground support technician to check whether, as reported by the passengers, there was a fuel leak in the tip of RH wing. At that time, engines 1, 2 and 3 were running.

The technician observed that there was a small patch of fuel on the ground below the wing and informed that it seemed there was no fuel leakage at that time. Then, according to his statement, he added: "No, no fuel drop,...turning engine 4" (“girando el cuatro” in Spanish) because he observed that engine 4 was starting.

The flight crew answered that they had not started engine 4, because they had a failure in the indication of EGT of engine 3, and that they were consulting the MEL. Afterwards, the CM-3 confirmed to the pilot in command that the MEL listed that indication as a "NO-GO" item, and therefore there was not possible to fly in these conditions. The crew informed the ground person that, as it was a NO-GO item, they had to return to the finger.

The technician asked whether they had reset the breaker, and was answered in the positive. The crew stated that even after the reset there were abrupt oscillations of EGT of engine 3, and that they were going to go back to the finger. They asked if the tug was still coupled to the aircraft. The technician said that it had already gone.

The crew then asked the technician about the possibility of either him calling the tug or returning taxiing with the engines thrust. The technician answered, according to his later statement, that the tug would require some time to return, and that they had three engines started; adding "whatever you decide".

The crew decided to come back by their own means, using engines 1, 2 and 3 and informed the ground person about that intention. He said he was going to unplug the interphone and inform the crew when clear on the left. He then unplugged the interphone and removed the by-pass pin and made a signal to the pilot in command, who answered with the same signal.

At 15:47:00 h the crew contacted the tower and said they had an indication problem in an engine, and added: “We are going to enter T1 again, if you do not have any inconvenience; we have pushed back only several meters.”

The ATC answered: “I am advising “Plataforma”” (airport’s operations personnel), wait a moment”, and then, at 15:47:30, commanded: “IBE 6403, enter T1” which was acknowledged by the crew, after ATC checked with operations that the finger was still free and there was possible for TF-ATH to occupy it again.

The finger operator was not advised that the aircraft was returning to the finger, which was still at the same position it had when was moved away from the aircraft to allow the pushback.

According to his statement, the pilot in command gently applied power to engines 1, 2 and 3. When the aircraft was at around 3 kt of ground speed, as indicated by the Inertial Reference System in the Flight Management System, he returned the thrust levers to idle. He then gently applied brakes and noticed no answer of the brake system at all. He looked at the accumulator pressure indicator in front of CM-2 and saw that 3000 PSI was displayed. He then pumped several times the pedals to discard a possible transitory failure, looked again at the pressure indicator and said to the copilot: “This does not brake! You brake!” The CM-2 applied then brakes but the aircraft did not

reduce the speed at all. He did not look at the pressure indicator at those moments.

As the pilot in command realized that there was some sort of problem with the brakes and he saw another Boeing B747 parked besides finger T-2 in front of them, he decided to minimize the damage as possible and deliberately turned the aircraft into the finger T-1 in an attempt to stop it.

In the mean time, two additional ground support technicians had been called to go to the aircraft as a result of the problem with the number 3 EGT indication. They arrived with a car and parked in front of the aircraft as they usually do in similar situations.

They noticed that the speed of the aircraft seemed to be excessive. They tried to make signals to the crew to reduce the speed but, as the aircraft appeared to come towards their car, they ran away from it to a safe distance. When one of the technicians looked again to the aircraft, he saw the thrust reversers extended and that the aircraft impacted with the finger.

The crash into the finger happened with the left part of the fuselage and the finger cabin was detached form the main part of the finger. The fuselage then impacted with the finger structure and came finally to a stop, with the circular metal part that forms the floor of the finger at the end of the finger tunnel being stuck into the fuselage just before the frame of door 2R.

The fuselage skin was initially torn along a line starting approximately in the vertical of the nose gear leg at approximately the height of the middle point between both pitot tubes, and three major punctures of the fuselage skin were produced in this area.

There also were multiple additional scratches and punctures to the rear of the fuselage up to the point where the floor of the finger had cut the skin in another major tear-off.

The fire fighting crew that was refueling another aircraft in parking T-2 noticed the impact of TF-ATH and quickly moved there to attend a possible fire. The ground traffic around the aircraft was stopped and three additional fire fighting vehicles were called to the area, along with ambulances and police services. No fire was noticed.

Although some people on board the aircraft were standing during the taxi of the aircraft back to the finger, and a cabin attendant was thrown against a bulkhead as a result of the deceleration due to the impact, no injuries were reported either on board or on the ground.

When the CM-2 looked at the power levers after the aircraft had come to a stop as a result of the impact with the finger, he noticed that the engines were already shut off. The pilot in command asked what had happened with the brakes and the CM-3 answered that he did not know.

The chief cabin attendant entered the cockpit to ask for instructions regarding the passengers. She was told to wait a moment, but finally used the Public Address System to tell the passengers that everything was under control and that they were waiting for air-stairs to disembark.

When she came downstairs the cockpit, she saw a stair situated in door 2R. Several people from the ground entered the aircraft, including a fire-fighter official, policemen, signalers, medical personnel and AENA representatives.

The fire-fighter told the CM-1 that there was no trace of fire or other problems on the ground.

Around 12 min later, an air-stair was placed in door 5L. Some passengers tried to go to door 2R with their hand luggage. The cabin attendants told them to go to the rear part of the aircraft. Every passenger left the aircraft through door 5L and went to the airport's terminal. The evacuation of the aircraft was reported as "normal", maybe "a little faster than normal".

The flight crew remained on board the aircraft for around one hour after the incident, and they were reviewing the systems and recalling the previous operation in an effort to figure out what could have been the problem.

Later on, they left the aircraft, which was moved from the finger at 19:52 h local time. The aircraft was then towed to the repair facility of the operator at Barajas Airport. The way from the finger to the maintenance facility has some downhill areas where it is necessary to apply aircraft brakes even when towed by a tug. On board the aircraft during the tow there was a ground technician seating on the left seat. He reported that the operation of number 4 hydraulic system, when energized by the electrical auxiliary pump (ACP), seemed to be correct, as it was the indication of hydraulic pressure. There was no loss of pressure during the whole towing process until the aircraft was parked in the apron of the maintenance facility.

The passengers embarked later on that night in another aircraft and departed to Mexico on 15 September 2002 at around 2:45 h local time.

1.2.- Injuries to persons

INJURIES	FATAL	SERIOUS	MINOR / NONE
FLIGHT CREW			18
PASSENGERS			355
OTHERS			

1.3.- Damage to the aircraft

The aircraft suffered major damage on the left forward part of its fuselage. There were four major punctures of the fuselage skin, with damage to the several fuselage frames. There was a puncture of around 60 inches between Station 350 and Station 410, at the height of stringer 27A, and tears and punctures between doors 1L and 2L. Photos of the damage are presented in Annex A.

1.4.- Other damage

The cabin of finger T-1 at Barajas Airport was detached from the main part of the finger and was left hanging from the left part of the finger. It was later on deliberately separated from the finger and left on the ground by support personnel, to eliminate the hazard to ground people and vehicles. There was major damage to most of the components of the finger cabin: tilting floor, rotating system, command stand, leveling system, and also to the air conditioning tube.

The outboard part of the finger tunnel structure was also damaged. The tunnel moved horizontally around 1 m until it hit the mechanical locks of the finger.

1.5.-Personnel information

1.5.1.- Pilot in command

Age/ Sex:	59 years old. Male
Nationality:	Spanish
License:	Airline Transport Pilot (ATPL(A))
License number:	1194
License renewal date:	07/02/2001
License Expiration Date:	07/02/2006
Medical Certificate valid until:	15/01/2003
Type Ratings:	B-747-100/-300; Flight instructor (FI); Instrument rating instructor (IRI); Type rating instructor (TRI)(B-747-100/300)
Last simulator training session:	28/05/2002
Last line inspection:	24/02/2002
Total Flying Experience:	19932 h
Flying Experience on the type:	1264 h, as pilot in command
Last 90 days on the type:	170 h

1.5.2.- Copilot on duty at the moment of the incident

Age/ Sex:	35 years old. Male
Nationality:	Spanish
License:	Airline Transport Pilot (ATPL(A))
License Number:	E/00010336
License Renewal Date:	08/11/2001
License Expiration Date:	08/11/2006
Medical Certificate Valid until:	26/10/2002
Type Ratings:	B-747-100/-300
Last simulator training session:	27/07/2002
Last line inspection:	18/08/2002
Total Flying Experience:	5201 h
Flying Experience on the type:	1100 h, as copilot
Last 90 days:	177 h
Rest before the incident flight:	4 days

1.5.3.- Flight engineer on duty at the moment of the incident

Age/ Sex:	57 years old. Male
Nationality:	Spanish
License:	Flight Engineer
License Number:	586
License Renewal Date:	02/09/2002
License Expiration Date:	10/03/2003
Medical Certificate Valid Until:	08/02/2003
Type Ratings:	B-747
Last simulator training session:	22/06/2002
Last line inspection:	12/06/2002
Total Flying Experience:	15551 h
Flying Experience on the type:	1424 h, as flight engineer
Last 90 days:	181 h
Rest before the incident flight:	4 days

1.5.4.- Relief copilot

Age/ Sex:	50 years old. Male
Nationality:	Spanish
Total Flying Experience:	9811 h
Flying Experience on the type:	1263 h, as copilot
Last 90 days:	214 h
Rest before the incident flight:	7 days

1.5.5.- Relief flight engineer

Age/ Sex:	53 years old. Male
Nationality:	Spanish
Total Flying Experience:	13968 h
Flying Experience on the type:	837 h, as flight engineer
Last 90 days:	206 h
Rest before the incident flight:	3 days

1.5.6.- Chief cabin attendant

Age/Sex:	53 years old. Female
Experience as cabin attendant on B-747:	7 years
Experience as Chief Cabin Attendant on B-747:	4 years
Latest refresher course fleet B747:	11/01/2002
Rest before the incident flight:	3 days

1.6.- Aircraft information

1.6.1.- Airframe

Make:	Boeing
Model:	B-747-341
Serial Number:	24106
Year of Manufacture:	1988
Registration:	TF-ATH
M.T.O.W.:	374850 kg
Holder:	Air Atlanta Icelandic
Operator:	Iberia
Total time/cycles:	58233 h/10370 cycles
Time/cycles since last A check:	452 h/63 cycles

The aircraft was dry-leased to Iberia.

1.6.2.- Previous maintenance

The aircraft had previously landed from La Habana and was parked in the finger T-1 on the day of the incident at 12:00 h UTC. During that flight, it was reported that the indicator of Exhaust Gas Temperature of engine 3 was inoperative. The needle fell up to 100 ºC and the flag appeared.

Additionally, when the aircraft was refueled in La Habana the indicator of “No. 2 Main” showed 34600 kg, whereas the measurement with stick gave 19.28

inch or 37800 kg. Therefore, there was a difference of 3200 kg. The aircraft took off there with 106700 kg as measured with stick. After 2 hours of flight, it seemed that the fuel quantity indication corrected and showed the correct amount of fuel. A total of 90700 kg was used in the flight. During the flight, after the central fuel tank was empty, fuel was transferred to it but only 1000 kg appeared on the indicator.

After the landing at Madrid, the number 3 EGT indicator was changed. According to the logbook notes, the aircraft was refueled “by stick” in Madrid and no difference with the indication in the cockpit was noticed. The ground personnel first proceeded to refuel the main tanks, and no increase of fuel on the central tank was noticed. Later on, the central tank was filled. Therefore, the issue of fuel indication was kept “in observation”.

On 9 September 2002, the automatic volumetric fuel shutoff unit had been replaced, due to a failure reported the day before.

1.6.3.- Refuelling procedure

The operator used to have a checklist to be used by the ground crews when the B-747 is going to be refueled. The procedure requested that the recent maintenance history of the aircraft was consulted to detect possible fuel system squawks. It is anticipated some possible spillage of fuel through the venting chamber situated in the wing tip. It is requested that fire fighting equipment be present. The circuit breakers of the “Control fuel overfill” and the “Volumetric shutoff unit” must be pushed. However, under some conditions it may be necessary to refuel with the “Volumetric shutoff unit” circuit breaker pulled (stick refueling). The procedure requested that any spillage of fuel was recorded.

There is no evidence that this checklist was followed during the refueling of TF-ATH that day.

1.6.4.- Brake System general description

The B-747 has four hydraulic systems. Systems 4, 1 and 2 are used for providing pressure to the brake system. Each system is pressurized by an engine driven pump (EDP) and an air driven pump (ADP) which move due to the air circulating in the pneumatic system. Therefore, when the APU is working and providing pressurized air to the pneumatic systems, ADP’s may provide pressure to the hydraulic systems.

ADP number 1 is used to provide hydraulic pressure to the body landing gear steering function, to assist steering during pushback turns.

Additionally, there is an electrical pump (ACP) powered by alternate current. This pump is installed on hydraulic system 4 with the intend of providing brake pressure for ground operations when pumps EDP and ADP are not

available to pressurize system 4, especially in the case of towing of the aircraft. This pump is devised to be used on the ground only, and can be provided with electrical current by the APU or an external source. When the ACP is selected, the light “LOW PRESS” extinguishes, which means that pressure is available from the ACP.

Every wheel of the main landing gear (16 wheels in total) has hydraulic brakes. The normal braking system is fed by hydraulic system number 4. Hydraulic system number 1 is used as an alternative to pressurize the brakes.

The brake pressure indicator shows the normal pressure of the brakes in the pneumatic end of the accumulator when either system 4 or system 1 are used.

The aircraft has a parking brake composed of a lever, a red light in the pedestal and in the control panel of the nose landing gear, and a control system moved by a motor. The parking brake works through the pressure of an accumulator charged by either system 4 or system 1.

The main mission of the accumulator is to keep the parking brake applied. The pressure of the accumulator will not stop the aircraft in the event of a loss of pressure of the normal system during takeoff.

The flight crew must be aware that the magnetically-held electrically driven hydraulic pump control switch will release (will go to OFF) when any of the following conditions occur: either No. 4 EDP or ADP start to pressurize the hydraulic system 4 and/or when electrical power is transferred from the APU or external power to airplane generators on early airplanes.

There is also a reserve brake system, which is fed by hydraulic system number 2. When the reserve system is used, the parking brake does not work.

The antiskid system regulates the braking action whether with the normal or reserve brake systems. This system does not work at low speeds (below 25 kt). However, if the amber light “Low speed brake release” is on due to a failure, it means that the antiskid system will not disengage during taxi maneuvers and, therefore, it must be manually disconnected.

1.6.5.- Controls, indicators, caution and warning lights of the brake system

The CM-3 may select the source of pressure for the brake system of the aircraft. Normally, system 4 is used for that purpose. However, the covered selector labeled “Normal brake source select” may be moved from the position “PRIM SYS 4” to the position “SEC SYS 1” to select hydraulic

pressure of system 1 to the brake system In this case, the green light “SEC SYS 1” illuminates.

The covered selector “ELEC PUMP HYD SYS 4” may also be moved to ON by CM-3 to provide pressure to system 4 through the electrical pump ACP.

If pressure to the system, as provided by any of systems 4, 1 or 2, is less than 1200 PSI, amber light “LOW PRESS” will light.

In the panel of CM-2 there is a pressure gage, labeled “HYD BRAKE PRESS” that indicates the pressure of the normal (not the reserve) brake system, and the pressure of the accumulator when there is no other source of pressure. The pre-charge of the accumulator is 750 PSI, and the normal working pressure of the system is 3000 PSI.

In the panel in front of CM-1 there is another amber intermittent light labeled “BRAKE SOURCE LOW PRESS” which appears when the pressure of the selected brake system is low and the switch of “ELEC PUMP HYD SYS 4” is in OFF. However, in some instances the control wheel makes it difficult the vision of this light from the eye’s position of CM-1.

The CM-1 can select the reserve source of pressure of system 2 using the switch “RESERVE BRAKE” he has in the panel in front of him. This switch is under guard.

There is another amber light “LOW SPEED BK REL” or “low speed brake release” in the panel of CM-3 that only appears on the ground in the event that the antiskid system will still work below 25 kt of speed. This light is also displayed in the central panel of the pilots.

1.6.6.- Normal procedures

The Operations Manual of the B-747, prepared by the Operator, revised on 10 August 2001, lists the different actions to be taken by every crew member (CM-1, CM-2 and CM-3) in the different phases of the operation. This manual is based in the generic Operations Manual prepared by the Manufacturer.

Those procedures were reviewed during the investigation. The parts pertinent to this event are briefly reproduced below. The list is normally read by CM-2 under request of CM-1, and will be answered by CM-1, CM-2 and CM-3 as applicable.

Text from the Operations Manual:

BEFORE ENGINE START:

“- Before engine start, CM-3 will check ACP is ON and there is pressure in the brake system. If that pump is inoperative, the switch of ADP 4 must be in

AUTO. Only in case of pushback, ADP 1 must be in AUTO (to have body landing gear steering).

For engine starting, the recommended [by the Operator] *sequence is 4-3-2-1, because after starting engine 4 there is normal hydraulic pressure available. However, if engines are started during pushback, the recommended sequence is the opposite (1-2-3-4). Anyway, the order can be changed if needed due to particular operational conditions or special request from the Authorities."*

The reason for this sequence was investigated. The Boeing Flight Crew Training Manual and Generic Operations Manual do not specifically recommend any engine starting sequence. It is stated that the engine start sequence may vary for many reasons, like location of ground support equipment, passenger loading ramps, pushback or towing requirements. However, during pushback, it is desirable to pressurize hydraulic system #1 first in order to have body landing gear steering available to assist in turning the aircraft as it is being pushed by the tow vehicle.

The starting procedure is initiated by the CM-3 by moving the ignition switch of the corresponding engine in GND START, and finalized by CM-1 who moves the fuel selector of that engine to IDLE or RICH, depending on the value of EGT, and says "Fuel on".

STARTING SEQUENCE:

"CM-1: when EGT increases, says "EGT"
If EGT does not increase in 25 seconds, CM-2: annunciates: "25 seconds"
CM-1 immediately moves the fuel selector to CUTOFF
CM-3 checks that the light ENG VALVE comes on and extinguishes and the light ACTUATOR comes on and extinguishes. The engine must be cranked for 30 seconds to eliminate fuel from inside the engine and then the ignition selector must be moved to OFF and Maintenance must be advised.

REMARK: If starting process of engine 4 is aborted, ACP switch of hydraulic system number 4 must be moved to ON again."

AFTER START CHECKLIST:

"This list is read by CM-2 at the request of CM-1, and answered by CM-1, CM-2 or CM-3 as required. That list must be carried out after the engines are stabilized at idle. This procedure guarantees that the aircraft is PREPARED and SAFE for taxi.

CM-3 checks that hydraulic system is in AUTO/NORMAL. It must be checked that the switch of ACP hyd. System number 4 is in OFF and under its cover.

Every switch of the hydraulic pumps ADP must be in AUTO, the pumps EDP must be in NORMAL, lights PRESS and LOW QTY must be off, and the pressure indicator of every system must be within the green band."

TAXI PROCEDURE:

Taxi area: CM-1 and CM-2 will check that the area on the left and on the right of the aircraft is clear for taxi.

Parking Brake: release. CM-1 press the pedals to release the parking brakes (the lever moves outside the "parking brake on" position) and checks that the lights PARK BRAKE and ANTI SKID HYD go off in the annunciator panel.

1.6.7.- Master Equipment List

Item 77-10, Chapter 9.01.77, page 7 of the Master Equipment List of the operator for the B-747, dated 11 December 2001, establishes that four EGT indicators are installed and the four are needed for dispatch of the aircraft. The digital indications may be inoperative provided that the corresponding needle operates normally.

1.7.- Meteorological information

The METAR of Barajas Airport (LEMD) at 18:00 h local time was:

141600Z 19005KT 140V220 9999 SCT050 SCT070 28/10 Q1014 NOSIG

Visibility was good. Weather is considered to have no influence in this incident.

1.8.- Aids to navigation

The parking position T-1 has a "Visual Docking Guidance System" that, according to the "AIP España" "gives azimuth guidance (shows the aircraft position with relation to the centre line of the parking area) and distance to the stop position (based on a laser radar measurement) that is provided by a display unit in front of the cockpit." This system is intended to replace a human signaler assisting the docking of the aircraft.

The display unit consists of:

- two lines of four alphanumeric characters through yellow fluorescent indicators, which give the crew information such as aircraft type, stand position, instructions to slow down, or to stop, or "TOO FAR", etc.

- azimuth guidance display, with a yellow fluorescent that shows the centre line and deviation arrows, and

- distance indicator to the stop position, consisting of four dashboards composed of yellow and black fluorescent lines organized in a vertical column.

The pilot taxiing an aircraft to that parking position should check that the displayed aircraft type is the appropriate, taxi in-line watching the guidance, and check that the distance indicator is completely yellow.

The distance indicator is activated at 16.2 meters before the stop position changing gradually from yellow to black color. At the stop position the distance indicator shows completely black and the word “STOP” appears in the upper presentation line. If the parking is correct, the word “OK” is also displayed. If the aircraft exceeds 1 meter or more the stop position, the indicator will show “TOO FAR” and it may be necessary to make a push-back.

If the aircraft speed exceeds 3 m/s (5.8 kt) the display unit will show the words “SLOW DOWN” to advise the pilot to reduce the entry speed.

This system was in a working condition the day of the incident, but it was not connected before the aircraft begun its taxi back to the finger.

1.9.- Communications

The communication systems of the aircraft, ground personnel and ATC worked properly during the incident.

The transcript of the communications between the aircraft and ATC ground movement (GMC) is included below (original in Spanish; translated into English for the purposes of this report):

ATC Time (UTC)	Station (121.700 MHz)	Text
15:38:45	IBE 6403	Madrid, muy buenas tardes, IBE 6403 en T1, listo retroceso *Madrid, good afternoon, IBE 6403 in T1, ready for pushback*
15:38:50	GMC	IBE 6403, muy buenas, retroceso aprobado en T1 *IBE 6403, good afternoon, cleared for pushback in T1*
15:38:54	IBE 6403	Autorizado retroceso en T1, IBE 6403 *Cleared for pushback in T1, IBE 6403*
....		
15:47:00	IBE 6403	Madrid, IBE 6403
15:47:06	GMC	IBE 6403, adelante / *IBE 6403, go ahead*
15:47:09	IBE 6403	Sí, tenemos un problema de indicación en un motor, vamos a entrar otra vez al T1, si no tiene inconveniente, sólo hemos hecho el retroceso unos cuantos metros. *Yes, we have an indication problem in an engine, we are going to enter again T1, if you do not have inconvenience, we have been pushed back only some meters*.
15:47:14	GMC	Aviso a Plataforma, espere un momento. *I am calling Plataforma, wait a moment*
15:47:30	GMC	IBE 6403, entre en el T1 / *IBE 6403, enter T1*
15:47:36	IBE 6403	Pues entrando en el T1, IBE 6403 *Then entering T1, IBE 6403*

There was a ground technician assisting the departure of the aircraft during the push-back. He was wearing headphones and boom microphone plugged to the aircraft. He prepared a report with the communications he held with the crew. The substantial part of those communications has been included in paragraph 1.1 “History of the flight” of this report.

1.10.- Aerodrome information

Madrid-Barajas Airport is major international airport with around 374000 aircraft movements in the year 2001. An average day of September, during the year 2001, had 1071 aircraft movements.

Before starting engines, the crew of the aircraft request clearance to Barajas-Clearance (130.075 MHz). Use of reverse power for leave the apron stands is not allowed, except in case of specific authorization being granted by the airport Authority. Engine regime must not exceed idle for parking positions in contact with the terminal building until the aircraft is aligned with the taxiway.

All surface movements of aircraft, towed aircraft, vehicles and people in the maneuvering area are subject to authorization by ATC, Barajas Ground Movement Control (GMC). It has two control sectors: GMC North (121.850 MHz) and GMC South (121.700 MHz), which is the sector where parking position T-1 is located.

GMC is responsible for:

- The control of every aircraft, vehicle and person on the maneuvering area, except for the runways in use.

- To issue clearances and instructions for towed push-back and taxiing of aircraft.

- Reporting to the aircraft the stand positions assigned by the Operations Centre (CEOPS).

The AIP España of Madrid-Barajas does not provide information on the boundaries between the apron and the maneuvering areas.

The mentioned AIP does include information on a “Visual Docking Guidance System” (see paragraph 1.8 of this report). On this information, some “instructions to the pilot” are furnished. However, it is not stated that it is mandatory to use the system when taxiing to a finger, or when or under which conditions it should be used.

There is no mandatory request in the AIP or in the “Reglamento de Circulación Aérea” to have a ground signaler or an automatic visual guidance system when taxiing an aircraft towards a finger or its final parking position.

The finger T-1 can be moved to adjust to the aircraft door’s height. It can also be moved along its longitudinal axis through a telescopic mechanism to contact the aircraft’s fuselage. However, the horizontal movement, in the direction perpendicular to its longitudinal axis is limited. This means that the aircraft must be precisely parked in a given position to allow the finger to be adjusted to the door. If the pilot passes that position by as little as one meter, it may be necessary to make a push back (see paragraph 1.8 above).

1.11.- Flight recorders

After the incident, the flight data recorder and the cockpit voice recorder were disassembled and reserved for investigation purposes.

1.11.1.- Flight Data Recorder (FDR)

The aircraft was equipped with a FDR SUNDSTRAND UFDR (Universal Flight Data Recorder), P/N 980-4100-DXUS, S/N 3873.

This equipment records 119 parameters with different sampling rates. It has duration of 25 h of continuous recording. That means that the newest data are continuously erasing the oldest recorded data.

It is important to note that there is no parameter related to brakes that is recorded in this FDR.

The FDR was taken to a laboratory with capacity for read-out. Several difficulties were experienced during the intended playback of the FDR, which was done at 12.5 times the recording speed. Those difficulties included areas with no data and loss of timing. After 5 of the 8 tracks of the tape had been downloaded the recorder got stuck which made it impossible to perform the readout.

The FDR was then transported to a maintenance shop with capability to repair that kind of equipment. The chamber of the tape was open and it was found that the tape reel appeared misaligned, and, therefore, was rubbed against the casing pulley. The tape was twisted and bruised in most of its longitude. It was suspected that the reel had an initial misalignment that was later increased by the playback process performed at the laboratory.

In the mean time, another reel was installed in the FDR and it was confirmed that the recorder worked in the proper manner.

It was intended to reassemble the unit after reinstalling the tape in the reel in the best possible way, using a low speed rewind. The FDR was then intended to be re-played in the laboratory. The process was closely monitored and for the 5 first tracks everything went normally, but at the end of track 0 it was noted some misalignment that ended with the tape out of the reel and the mechanism blocked in the change between track 0 and track 1.

The file of the data obtained so far was closed, the tape placed inside the pulleys and another file was created for the remaining tracks. In this way, the download of the eight tracks was completed, although serious doubts existed on the usability of the data.

When the raw data were converted to engineering units, it was noticed that the incident is not recorded. The data passed from the last landing in Madrid from La Habana to the cruise recorded 25 hours before (flight Miami-Madrid, 13 September 2002). Just before the transition between those two flights, in frame 10775, the crash with the finger should have been recorded.

It was considered that the lack of data was not due to inoperability of the recorder during the incident, but to the several voids in the data recovered due to degradation of the tape due to brushing, dragging and twisting due to misalignment.

Actually, a total of 17 h and 52 minutes of data were recovered, and therefore around 7 h were missing, with a random distribution along the tape and duration of the voids. The sum of the noted jumps, with a given start and end inside a flight, was 5 h and 10 min. That meant that there were still around 2 hours missing through the tape.

It was concluded that the data corresponding to the incident were most probably missing and, in any case, they could not be recovered by the available means of the laboratory.

1.11.2.- Cockpit Voice Recorder (CVR)

The aircraft was equipped with a CVR FAIRCHILD P/N 93-A100-30, S/N 6437, which provides 30 minutes of continuous recording of the sounds in four channels: Pilot communications through the boom microphone, Co-pilot communications through the boom microphone, Flight Engineer communications through the boom microphone, and cockpit ambient microphone (channel 4)

The CVR was replayed in the facilities of the CIAIAC. A CD-ROM with the recorded sounds of the four channels was prepared. That CD-ROM had a lot

of noise and, additionally, some of the voices sounded very weak, especially voices coming from people situated in the rear part of the cockpit. That made most of the conversations unintelligible.

The sound was then further treated and some of the nuisance noise could be removed. However, still a lot phases and statements of the conversations remained unintelligible.

The CVR had a total of 30 minutes of sounds recorded but did not contain any recording of the event itself, i.e., the moment in which the aircraft taxies back to the finger and crashes into it. As the aircraft remained powered afterwards, those moments had been overwritten, and the recorded sound corresponds to the conversation between the crew members talking about what happened, trying to figure out the cause of the incident and discussing the content of the report they were going to prepare.

It is unknown the ATC time when the aircraft was de-energized; therefore it is not possible to know exactly when the recorded conversations took place. According to different statements, it could be estimated that the crew spent around 1 h inside the cockpit after the incident, reviewing and discussing about the whole event.

It is not considered necessary to the purposes of the investigation to reproduce the complete transcript of the conversations on this report. As indicated in the previous paragraph, they were recorded after the actual event.

As a summary of the information provided by the CVR, conversations recorded show that the crew thought of different possibilities of what could have been the problem. The crew carried out the complete “after shutdown” checklist.

1.12.- Wreckage and impact information

The aircraft had crashed into the finger suffering major damage on its left side and breaking the cabin of the finger in the process.

The first mark of the fuselage was in a point situated horizontally in the vertical of the nose landing gear and vertically at the height of the middle between both pitot tubes. The marks ended just at the beginning of the frame of door 2R, where the rotating roof of the finger was embedded in the fuselage. That means that the aircraft moved for twelve meters after the initial contact with the finger. During that movement, rubbing and scratching happened and appreciable horizontal forces were applied to the aircraft by the finger structure, as noted by the damage and deformation produced.

The nose wheel appeared around 5 m away from the taxi yellow line. The inboard wheels of the RH body landing gear were just above the taxi yellow line. The aircraft longitudinal axis was rotated around 30 degrees to the left of the taxi yellow line.

Several tire marks were clearly noted on the ground. The marks clearly led to the wheels of the RH wing landing gear. Additionally, the marks, that extended for a length of around 10 m, had and intermittent nature regularly spaced that was more noticeable for the inboard wheels of the RH wing landing gear. The marks of the outboard wheels were more continuous. The marks were arranged in a more or less straight line that showed an angle with the yellow guidance line similar to the final angle that the fuselage had with that line, indicating that the turn against the finger had taken place previously.

Marks of other wheels were not clearly noticeable.

The aircraft had been in contact with the finger for around 12 m until it came to a stop.

A walk around of the aircraft, three hours after the incident, still showed marks of fuel spillage on the outboard lower part of the RH wing. The marks led to the fuel venting chamber of the aircraft.

In Appendix A, some photos of the damage to the aircraft and the finger are included. A drawing of the final position of the aircraft is presented in Appendix B.

1.13.- Medical and pathological information

Medical Services of the airport were called to the aircraft, but no personal damage to passengers, crew or ground personnel was reported.

1.14.- Fire

There was no fire as a result of the collision. Initially, a fire fighting vehicle that was assisting the refueling of another aircraft at finger T-2 moved quickly to finger T-1 when they noticed the crash into the finger. Afterwards, three additional vehicles went to the scene. They were prepared to control any possible fuel spillage and were watching the finger to prevent that detached parts could pose any hazard to people or vehicles.

After the passengers disembarked under their coordination and supervision, the firefighters were authorized by airport officials to leave the place of the incident.

1.15.- Survival aspects

According to several statements of witnesses, there were passengers standing on the cabin when the taxi back to the finger was initiated. There is no exact data of the deceleration suffered by the aircraft during the impact with the finger, since no useful data could be extracted from the FDR.

Some witnesses said that a loud bang was noticed inside the cabin at the moment of the impact. A person was thrown against a bulkhead. Other witnesses in the passenger cabin said that they noticed the impact with the finger because two loud noises. The first noise was small and sharp and the second more violent.

Some people from the emergency services (fire fighters, policemen, medical) boarded the aircraft through door 2R. The passengers were disembarked through door 5L, that is, the rearmost door on the left side (the side of the finger) of the fuselage. No emergency was declared and the evacuation of the aircraft was described as normal, with no rush. The air stair arrived at door 5L around 12 minutes after the crash. The last passenger left the aircraft around 35 min after the arrival of the air stair.

1.16.- Tests and research

1.16.1.- Statements of witnesses

Several witnesses were interviewed during the investigation. Although most of their statements have been used to describe the event in previous paragraphs of this report, their statements are summarized below. Only the most important parts of the information they provided are included.

1.16.1.1.- Pilot in Command

The pilot in command stated that after arriving to the aircraft at around 17:00 h, they noticed that there was an important spillage of fuel on RH wing. While they were completing the pre-start checklist, the chief cabin attendant entered the cockpit to advise that some passengers were noticing the fuel spillage. During the whole event, the aircraft was energized by the Auxiliary Power Unit. Afterwards, they started engines 1 and 2 while pushing back. Then they started engine 3 and noticed oscillations in its EGT indication. The needle even reached zero during the oscillations. He told the CM-3 to look the Minimum Equipment List. During the starting sequence of engine 3, the chief cabin attendant entered the cockpit again to say that some passengers were complaining because they were seeing again fuel falling from RH wing.

The crew knew that this was a normal situation due to an excess of fuel during the refueling of the aircraft.

The CM-3 informed that EGT of any engine was a no go item and therefore the CM-1 decided to return to the finger by their own means, as the tow vehicle had left after the pushback. When ATC authorized them to taxi back to the finger, he told the ground technician to leave and, using engines 1, 2 and 3, initiated the taxi with gentle power. When the aircraft started moving, he retarded the thrust levers. Speed was around 3 kt at the most. When the aircraft was approaching the finger, he gently applied brakes and noted no braking action at all. He looked to the pressure indicator in the CM-2 panel and saw 3000 PSI of pressure. He then pumped the pedals several times to discard the possibility of a temporary failure of any kind and looked again to the pressure indicator. He then said: “This does not brake. You brake” addressed to the CM-2, who answered that their brakes did not work either.

Taking into account every possibility, specially the fact that they had another B-747 parked in front of them, he decided to deliberately steer the aircraft into the finger to stop it with the least possible damage.

The CM-1 was very categorical in his statement that he never tried to activate the thrust reversers of the three engines that were running. He thinks that activating the reversers could even have worsened the situation.

He also stated that they kept engine 3 running and that CM-3 asked: “Will I start it? [referred to engine 4]” and CM-1 answered: “Do not start it”. He said that engine 4 was never cranked. There were not signalers on the ground to guide their taxi back to the finger, but in the opinion of CM-1, they were only 50 m away from it. He thought that, if the visual docking guidance system was on, he would follow it. Otherwise, it is possible to stop the aircraft more or less in the adequate position mentally assessing the position of the aircraft using the yellow lines painted on the ground, on the sides of the central line. The visual system was not connected any time during the taxi, but he has parked without that system other times using the ground marks.

He did not address the passengers at any time. He told the chief cabin attendant to take care of that, but did not know what she finally did. During the taxi, he knew that there were passengers standing.

He said that no warning or caution light was lit in the CM-1 panel during the event. He did not know about lights on the CM-3 panel. As previously stated, he saw 3000 PSI on the accumulator indicator (CM-2 panel) the two times he looked at it, even after having pumped the brakes several times.

1.16.1.2.- Co-pilot

The copilot remembered that there was a spout of fuel from RH wing when they arrived to the aircraft. There was a strong smell of fuel. He remembered

boarding the aircraft at 16:50 h local time, and time of chocks out was around 17:38 h local time, which meant that they had around 1 h left before exceeding the established period of activity.

Once on board, the crew completed the before start check list, and, after clearance, started engines 1, 2 during pushback which was done straight backwards. Then the ground technician that was assisting the starting said (referring to engine 3): “Clear” (“Libre el tres”) and the CM-1 applied brakes because he understood “Parking brake”. The aircraft stopped sharply as a result of that brake application. After the misunderstanding was clarified, engine 3 was started and the tow vehicle left. It was noticed the EGT indication had violent oscillations. The CM-3 informed that this was a no-go item and the CM-1 decided to return to the finger. The process took around 5 min, since the moment the tow vehicle left to the moment they started the taxi. The aircraft was at that moment still aligned with the finger and 40 m or 50 m away from the finger.

The CM-2 said “Clear on the right”, and during the taxi he was looking outside the aircraft to watch clearance with obstacles and other aircraft.

When he heard the CM-1 saying “It does not brake” he also applied brakes without any positive result. He did not think that the aircraft was faster than normal during the taxi. After the aircraft impacted the finger and stopped, he looked at the thrust levers and saw that the engines were already shut down.

He remembered that the aircraft did not show any sign of stopping when the brakes were applied. He also recalled that, when they first arrived to the cockpit, he saw that the accumulator was low through the indicator, and asked CM-3 to provide pressure. CM-3 connected the auxiliary electric pump (ACP) and the accumulator was quickly charged.

When they applied brakes during the taxi, he did not look at the accumulator indicator. He could not tell whether or not there was pressure at that time. He did not know whether engine 4 was cranked for some time. He was positively sure that this engine was not started at any time. The visual docking guidance system was off all the time. He did not saw whether or not the thrust reversers were deployed. He was looking to his right, outside of the aircraft most of the time during the event.

1.16.1.3.- Flight Engineer

He remembered that there were two previous maintenance squawks: EGT 3 indicator inoperative and unreliable fuel quantity indications. He arrived to the aircraft and saw that a lot of fuel was spilling to the ground during the refuel of main tank number 2. The fire fighters were applying water to the spillage.

He stated that engines 1 and 2 were started during the pushback. The CM-1 applied brakes at that time and some excess fuel fell to the ground through

the venting chamber. In the mean time, the chief cabin attendant entered several times the cockpit to advise on the bad mood of some passengers. After engine 3 was started, and as some erratic EGT indication was noted, he looked to the manuals and found that it was a no-go item. Then the taxi back to the finger was initiated. When he heard that the aircraft did not brake, he remember looking at the auxiliary electrical pump (ACP) and seeing that it was ON (the cover was lifted) and that there was 3000 PSI of pressure in hydraulic system 4. From his position, it is possible to see the accumulator indicator.

He acknowledges that he could have connected hydraulic system 1, but it did not think of it as everything happened in a very short period of time.

1.16.1.4.- Relief Co-pilot

The relief co-pilot stated that he was seated on the cockpit, together with four additional people: CM-1, CM-2, CM-3 and a passenger.

The checklist completion and the subsequent pushback were normal. At the end of the pushback, with engines 1, 2 and 3 already running, the EGT indication of the latter descended until reaching zero degrees. It is normal some descent of EGT after the start, but not so much as in this occasion.

He could not say whether or not engine 4 was cranked after the start of engine 3. He helped CM-3 to look up the manuals and they found that EGT indication was a no-go item. The tow vehicle had already left and the CM-1 decided to return to the finger by their means, probably to avoid further delays in the operation.

He does not remember that any checklist was read after engine 3 was started and before the taxi back to the finger.

When the taxi started, he remembers that brakes were applied and he thinks there was some sort of positive braking. When the aircraft was on the line to the finger, he heard “It does not brake” and it seemed to him that the CM-1 applied brakes twice, as did the CM-2. He saw the finger approaching, and believes that the pilot drove the aircraft into the finger.

During the event, the chief cabin attendant entered the cockpit at least a couple of times. In one of them she was worried and asked the CM-1 to address the passengers. However, it was the moment when the decision to return to the finger was being made. Later on, she entered the cockpit again but it was close to the moment of the crash into the finger, maybe the latest two seconds.

He did not see the pressure of system 4. He heard subsequent comments that it was 3000 PSI. He did not see any light on the caution/warning panel of the commander. He cannot see those lights from his position. He could not

tell whether the ACP jumped or was disconnected during the starting sequence of the engines. He neither saw whether or not the thrust reversers were deployed.

The speed during the taxi was normal, according to his recollection of those moments.

The aircraft was around 50 m away from the finger when the taxi was initiated. After the crash, they were around 15 m or 20 m inside the cockpit, trying to figure out what happened.

He has previously seen fuel spillage from the excess chamber in other B-747 during normal taxi.

1.16.1.5.- Relief Flight Engineer

The relief flight engineer remembers that the flight was around 5 h delayed with respect to the scheduled departure time. When they arrived to the aircraft, the CM-1 told him to go to the passenger cabin during the takeoff, because his seat in the cockpit was going to be occupied by another person.

He occupied a place in the first class cabin. From his position, he could not see the engines or the wing of the aircraft. He saw that the chief cabin attendant entered the cockpit several times, to advise that some passengers were complaining. He did not see anybody standing during the taxi.

During the event, he noted some pulls at some point. He did not notice an inadequate speed during the taxi. After the crash, he entered the cockpit to help the active crew, and he heard some comments they were making at that point.

1.16.1.6.- Chief cabin attendant

She remembers that the boarding of the passengers took around 50 min. Afterwards, doors were closed and evacuation ramps armed. She addressed the passengers following the normal procedure. Some passengers were worried because they had seen a lot of fuel falling from the aircraft while boarding it.

Then the pushback started. The cabin attendant located besides door 5R advised that some passengers had seen fuel spilling from the wing, and some of them took their hand luggage and started walking towards the front of the aircraft complaining. One of the leaders of what was described as a kind of riot or uprising was a passenger with symptoms of alcohol consumption.

She went to the cockpit and asked the CM-1 for instructions. She did not receive clear indications on what to say, as the crew were deciding to taxi

back to the finger. She said through the Public Address System that there was no problem and asked the passengers to take their seats.

At that point, other cabin attendants were providing information about a lot of passengers standing and complaining.

She remembered entering twice the cockpit before the crash.

She noted the incident because she saw the finger approaching through the windows and heard a strong metallic noise and impact.

After the crash, she went to the cockpit, learned what had happened and asked for instructions. She addressed the passengers, stating that everything was under control and that air stairs were on their way.

Then a stair was located at door 2R and emergency personnel boarded the aircraft. The passengers left the aircraft through door 5L, in around 35 min.

After the last passenger had gone, she also left the aircraft and saw a lot of people around the aircraft.

1.16.1.7.- Ground observer

A person that was located inside the terminal building, in front of the aircraft when it was parked at finger T-1, saw the tow vehicle moving the aircraft away from the finger. The person had no specific aeronautical knowledge, but used to work at the airport and had seen a lot of aircraft taxiing.

When he looked again to the aircraft, it was coming towards the finger alone, without being towed. He thought the aircraft was coming very fast, taking into account that it was close to the finger and other vehicles and aircraft.

He saw that the aircraft did not reduce the speed until it crashed into the finger. He noted that after the crash the nose of the aircraft descended, as well as the gear shock absorber, in his words, looking as if the aircraft had braked at the last moment and the inertia had made the fuselage to move after the wheels stopped.

He did not notice anything special regarding the status of the engines. The passengers left the aircraft through the door located on the left rear part of the fuselage.

He did not see anybody around the aircraft when it was taxiing.

1.16.1.8.- Ground technicians

The statement of the technician that was assisting the aircraft during the pushback has been reproduced in paragraph 1.1, as well as the statement of

one of the maintenance technician that approached the aircraft after the EGT problem was noticed. This latter person said that the aircraft was approaching at high speed with the thrust reversers deployed. The technician that was supporting the operation from the ground saw engine 4 rotating for a while.

1.16.2.- Static test of the brake system

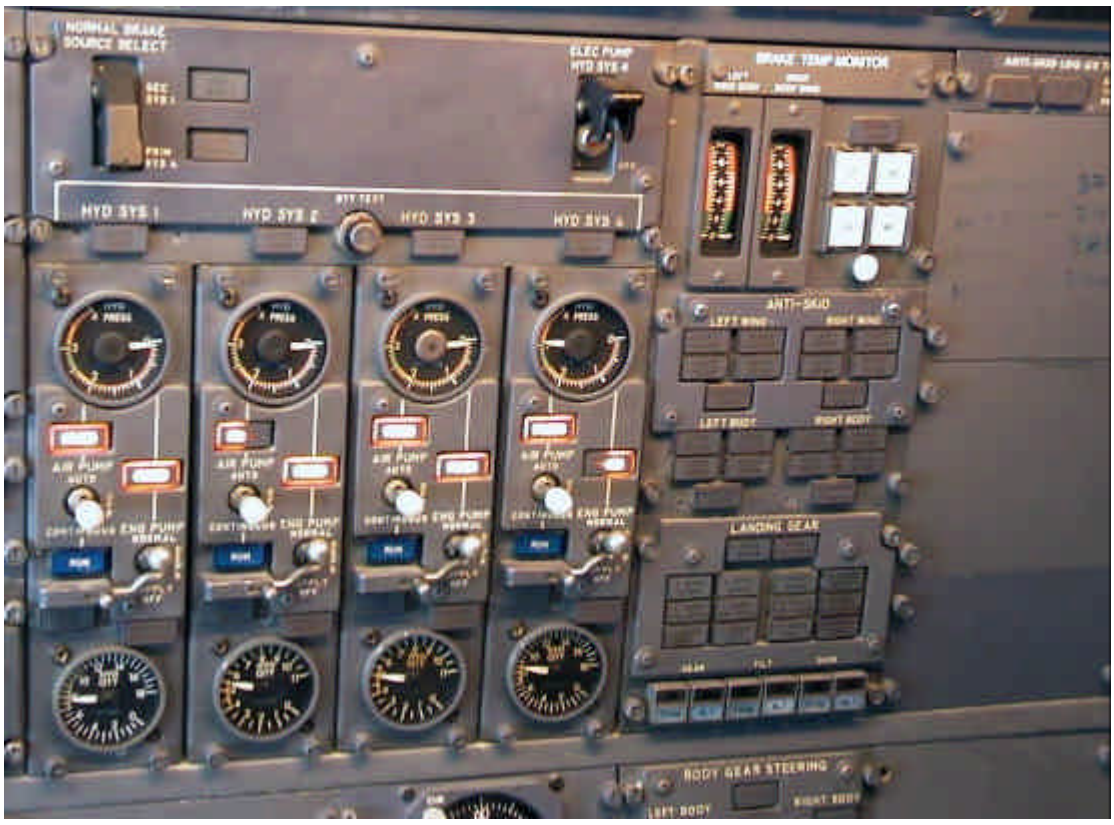
After the incident, the aircraft was towed to a maintenance facility of the operator at Barajas Airport. During that tow, the brakes of the aircraft were used and a normal behavior was noted. The FDR and CVR were removed from the aircraft and kept under custody.

The operator was requested to preserve the hydraulic and brake systems of the aircraft as they were after the incident for investigation purposes. It was stated that no work or repair could be performed on those systems until further instructions.

It was requested to perform a test to ascertain the status of the brake system of the aircraft. For that purpose, the brakes troubleshooting procedure detailed in the Aircraft Maintenance Manual (Ch. 32-41-00, paragraph 2, pages 102 and 105) was carried out in presence of members of CIAIAC. Pressure gauges were installed in the brake of every wheel to be sure that adequate pressure reached the wheels during the test.

The test consisted basically of pressurizing system 4 and measuring pressures after depressing brake pedals of captain and copilot, putting landing gear control lever in the UP position, then pressurizing system 1 and measuring pressures and noting warning lights, and then pressurizing system 2 and measuring pressures and noting warning lights.

Gauges installed on the brakes of TF-ATH



CM-3 Panel. ACP switch (labeled “ELEC PUMP HYD SYS 4”, cover lifted) noted. Pressure gauge of Hyd. System No. 4 shows 3100 PSI.

The results of the test were satisfactory according to the PASS criteria of the maintenance manual. The conclusion was that the system worked all right and therefore it was fully operative.

Additionally, it was noted that the electrical pump (ACP) was immediately and automatically disconnected at the very first crank of engine four.

1.16.3.- Taxi test of the brake system

After the static test, the system was considered operative in accordance with the manufacturer's instructions as stated in the Maintenance Manual. However, doubts existed regarding the actual operational or dynamic scenario that was faced by the crew the day of the incident.

There were statements of some crew members that 3000 PSI of pressure had been noted in the system during the event and still the aircraft did not brake at all.

Therefore, it was decided to perform a taxi test trying to simulate and reproduce the conditions of the day of the incident.

The test was carried out on 27 November 2002 at 13:35 h, in an appropriate test area at Barajas Airport. The operator had been requested to keep the hydraulic and braking systems of the aircraft unmodified since the date of the incident. Some structural repair work was carried out and some engines and other parts were dismounted from the aircraft in the mean time.

The taxi test was done in accordance with test plan Ref. ME3/02134 Rev. 3 (22-11-2002) and had a qualitative nature. Before that, a brake system test (static, that is, only pressures are checked without moving the aircraft) in accordance with Boeing Maintenance Manual was carried out and its result was "system OK" (see paragraph 1.16.2 above).

The purposes of the taxi tests were:

- to simulate a possible scenario encountered during the incident IN-69/2002 that happened at Barajas Airport on 14 September 2002. Conflicting information has been gathered regarding the incident and pressure available at that moment.

- to check that no "hidden" failures existed within the system (i.e. failures that could remain undetected through the normal static brake system test), even though the probability of this was considered very low.

Ground marks during the taxi tests (continuous and lightly marked)

Ground marks the day of the incident (intermittent and strongly marked)

The main intent of the test was to check the capability of the accumulator to stop the aircraft from a slow taxi speed. Information gathered from specialists indicated that the braking capability of the accumulator is not guaranteed even from small speeds (the operations manual of the Operator, section 12.32.10, 15 Nov 2000, says "the accumulator pressure will not stop the aircraft if during take off normal brake pressure is lost", but it does not cover the case of taxi operations).

The taxi test was considered to be of low hazard, if any, as every one was aware and advised of its nature, three additional braking systems were available in case of need and enough free apron space to do safely the test had been requested in advance.

The weight of the aircraft was estimated at around 205000 kg (as opposed to 364000 kg the day of the incident). The ramp were the tests were carried out was found to have a slight down slope. There was light rain during the last part of the test. That precluded the ground marks from being noted in detail (see attached photo).

RESULTS OF RUN 1

After pre-start checklists were completed, the a/c was towed backwards during approx. 50 m. During that pushback, engines 1, 2 and 3 were started. Parking brake was on and engine 4 was "cranked" a little bit by CM-3, but the start sequence was not completed by CM-1. The electrical pump (ACP) was noticed to automatically disconnect at the very beginning of the crank, almost immediately.

The tow vehicle then left. When the aircraft was ready for taxi forward, the parking brake was put to off after the CM-1 pressed the pedals. As the CM-3 asked for some clarifications regarding the condition of some systems for the taxi "back to the finger", the CM-1 kept the pedals pressed, and therefore the accumulator pressure bled off quickly. Before beginning the actual taxi test, there was no pressure available and the a/c started moving slightly forward even though the CM-1 kept the pedals pressed, as a result of engines 1, 2 and 3 idle thrust and the slight down slope. Therefore, a real no-brakes situation was simulated. The ACP was then connected again by CM-3 (without any rush) and in less than 2 seconds there was pressure available and the accumulator was charged again. The a/c was then stopped using the brakes in a normal mode. An estimated distance of 15 m was consumed during the whole manoeuvre.

The run was then repeated from that point. Parking brake was ON, accumulator was charged, ACP was OFF, then parking brake was released to OFF, pedals released and some power added. The a/c started taxiing. Accumulator pressure was still around 3000 PSI. When the normal (estimated) taxi speed was reached, CM-1 applied brakes continuously. Accumulator pressure descended to 1000 PSI after the pedal application and moderate deceleration was noted. Finally, the a/c stopped in less than 2

seconds with an estimated distance of 4 m. Parking brake was then put ON, with accumulator pressure of 800 PSI (NOTE: if parking brake is not applied to "trap" the accumulator pressure, and the pedals are kept pressed, the pressure goes to zero very quickly).

Recorded results for RUN 1:

- status of ACP: OFF.
- pedal force: Similar to normal braking; no special feeling noted.
- deceleration of the a/c: moderate.
- accumulator pressure: descended to 800 PSI, and then kept by parking brake.
- warnings and cautions in the CM1 panel: "brake source low pressure" lit.
- time and distance to stop the a/c: approx. 2 sec. and 4 m.
- tire ground marks: not noted.

RESULTS OF RUN 2

The a/c was then towed back for approximately 40 m, and then the tow vehicle left. With parking brake ON, ACP was OFF, ADP 4 was OFF, Normal brake source select was selected by CM-3 to SYS 1; with this action, the accumulator was fully charged again in around 2 seconds. Parking brake was then released and the a/c started taxiing forward with engines 1, 2 and 3. When normal taxi speed was achieved, CM-1 applied brakes and, as expected, the a/c was quickly brought to a stop with heavy deceleration.

- status of ACP: OFF.
- pedal force: Similar to normal braking; no special feeling noted.
- deceleration of the a/c: heavy.
- accumulator pressure: descended to 2000 PSI briefly; quickly recovered to 3000 PSI.
- warnings and cautions in the CM1 panel: None.
- time and distance to stop the a/c: approx. 1 sec. and 3 m.
- tire ground marks: continuous.

RESULTS OF RUN 3

From the previous position, with parking brake ON, ACP was ON, ADP 4 was OFF, Normal brake source select was selected by CM-3 to PRIM SYS 4. Parking brake was then released and the a/c started taxiing forward with engines 1, 2 and 3. When normal taxi speed was achieved, CM-1 applied brakes and, as expected, the a/c was quickly brought to a stop with heavy deceleration.

- status of ACP: ON.
- pedal force: Similar to normal braking; no special feeling noted.
- deceleration of the a/c: heavy.
- accumulator pressure: descended to 2000 PSI; recovered to 3000 PSI.

- warnings and cautions in the CM1 panel: None.
- time and distance to stop the a/c: approx. 1 sec. and 3 m.
- tire ground marks: continuous.

RESULTS OF NEW RUN 1

The run 1 (brake only with accumulator) was then repeated again from the previous point. Parking brake was ON, accumulator was charged, ACP was OFF, and then parking brake was selected to OFF, pedals released and some power added. The a/c started taxiing. Accumulator pressure was still around 3000 PSI. When the normal (estimated) taxi speed was reached, CM-1 applied brakes continuously. Accumulator pressure descended to 1000 PSI and moderate deceleration was noted. Finally, the a/c stopped in less than 2 seconds with an estimated distance of 5 m. Parking brake was then put ON, with accumulator pressure of 800 PSI. The distance from the release of parking brake was approx. 36 m.

Recorded results for NEW RUN 1:

- status of ACP: OFF.
- pedal force: Similar to normal braking; no special feeling noted.
- deceleration of the a/c: moderate.
- accumulator pressure: descended to 800 PSI after the first pedal application, and then to kept by parking brake.
- warnings and cautions in the CM1 panel: "brake source low pressure" lit.
- time and distance to stop the a/c: approx. 2 sec. and 5 m.
- tire ground marks: continuous (photo available).

INITIAL CONCLUSIONS OF THE TAXI TESTS:

- ACP disconnects itself at the very first "crank" of engine #4
- If the starting sequence of engine #4 is discontinued, a deliberate human action is required to avoid leaving the a/c without any brake system available.
- There is no "warning" for this situation. However, the Operations Manual advises that the ACP must be connected again if the starting of engine #4 is discontinued ("Normal Procedures", 2.01.32, 15-Nov-2000).
- Accumulator pressure was demonstrated enough to stop the aircraft (at the noted weight) from a low taxi speed, but it is quickly bleed off if continuous pressure or several touches are applied to the pedals.
- If the crew is not aware of the abnormal situation, when normal brake pressure is not available, it is likely that accumulator pressure will be inadvertently and quickly wasted well before being actually used for stopping the a/c.

1.17.- Organizational and management information

1.17.1.- Ground movement at Barajas Airport

The organizational information of Barajas Airport pertinent to the purposes of this incident has to do with the boundaries between the maneuvering area (to be under the control of the Air Traffic Control services) and the apron area.

It is not clear in the AIP Spain where starts and ends each of those parts. Some areas of the apron are not visible from the tower where the ground movement ATC controllers are located.

It is not stated the responsibility of every department on the control of those areas. Therefore, in the case of an aircraft taxiing towards a parking position, inside the apron, the mission of the ATC ground movement controller is to authorize the movement after checking with the Operations Department that a given parking position is free and therefore may be occupied by the incoming aircraft.

As detailed on paragraph 1.10 above, the AIP states that the ATC Ground Movement Control (GMC) has the responsibility of the control of every aircraft, personnel and vehicle movements on the maneuvering area except for the runway or runways in use. In practice, this means that they are responsible of movements in the taxiways and maybe part of the apron, but nothing is concluded in the AIP about the apron itself. In any case, GMC does provide separation between the aircraft and other aircraft all the time, but not separation between the aircraft and vehicles and personnel in the apron area. Additionally, some taxiways cross or are inside the apron, and therefore they are under the control of the ATC because they are a part of the maneuvering area.

If the pilot notices that there is no guidance available to perform the parking or docking maneuver, in the form of visual docking guidance system or human signaler, he usually requests the ATC to be provided with that guidance. In this case, the controller advises the Operations Department which sends an operator to switch on the visual docking guidance system or send a “PAPA” vehicle with signalers to assist the aircraft.

However, in practice, if the pilot of the aircraft does not request any help to dock the aircraft, there is no procedure to automatically provide him with that assistance.

1.18.- Additional information

1.18.1.- Refresher training of the B-747 crews

To keep the type rating on their licenses, crews must attend recurrent training consisting of Refresher Courses, Rescue Courses, Dangerous Goods Courses, and line checks.

The refresher courses are attended approximately every 6 months, in a cycle of two years. After the cycle is completed, the crew member will have reviewed every system of the aircraft, and will have performed several manoeuvres that will guarantee that he or she keeps his or her proficiency. The crew member must also show theoretical knowledge of the systems in the corresponding exams.

The refresher training consists of two sessions of flight simulator, with the corresponding briefings and de-briefings.

The syllabus of the refresher training courses that were reviewed did not contain specific training or simulation of malfunctions of the brake system during pushback or taxi of the aircraft.

1.18.2.- Admission to flight deck and flight crew members on their positions.

According to JAR-OPS 1.100, an operator shall ensure that no person, unless a member of the flight crew assigned to a flight, is admitted to or carried in the flight deck unless that person is an operating crew member, a representative of the Authority, or permitted by, and carried in accordance with the instructions contained in the Operations Manual. It is stated that the final decision regarding the admission to the flight deck shall be the responsibility of the commander.

JAR-OPS Subpart P specifies the content of the Operations Manual of a given operator. Paragraph 8.3.12 states that there will be conditions to grant admission to the flight deck to people other than the flight crew.

Paragraph 8.3.10 states that the Manual should also include the requirement for the members of the crew to be on their posts or in designated seats in the different phases of the flight or when needed for the sake of safety. The Manual of the Operator already includes that requirement.

1.19.- Useful or effective investigation techniques

None.

2.-ANALYSIS

2.1.- General circumstances of the flight

The review of all the facts gathered, as described in the previous paragraphs, leads to the conclusion that some of the passengers that boarded that flight with destination to Mexico City, with an estimated flight time of 9.5 h, were in a state of mind that included some anxiety and stress.

The main reasons for that mood are:

- The flight had a delay of around 4 hours.
- The passengers thought the aircraft had a maintenance problem and that was the cause of the delay.
- During the boarding, they saw an important amount of fuel spilling from a tank.
- Once the pushback started, they noticed additional fuel leakage.
- When they started complaining, they did not receive clear or convincing explanations from the crew.

According to several statements, alcohol cannot be discarded as an additional negative factor that influenced the behavior of some passengers.

This situation eventually led to several passengers complaining to the cabin crew members and saying that they refused to fly. The upsetting was transmitting to other passengers and finally reached the flight crew through the chief cabin attendant, who entered several times the cockpit to inform on the situation and to suggest that the pilot in command addressed the passengers.

The chief cabin attendant remembered entering twice the cockpit. The words “riot” or “uprising” [“amotinados”, “insurrección”] were used to describe the situation among the cabin crew members and also to the flight crew.

This factor could have affected the flight crew state of mind and performance, introducing a disturbing factor during the pushback, period of decision about what to do with the flight, and later taxi back to the finger. Those were moments of some workload inside the cockpit, including close monitoring of the parameters of engine 3, looking up the manuals to find the influence of the EGT indicator failure, decision on what to do with the flight, and, once the decision to return to the finger was made, decision on how to return to the finger, since the tow vehicle had already left

On the other hand, the flight crew were probably also affected by the delay that the flight had got so far. In addition to the normal upset that every delay

produces in any person, they had around 1 h left to takeoff because, otherwise, taking into account the scheduled time of the flight to Mexico, they could have exceeded the maximum period of aerial activity for flight crew members.

The sequence of the different events that concluded with the crash into the finger has been deducted using the different statements of witnesses and other evidences. As it was described in paragraph 1.11, FDR data were not available. Neither was sound recording of the event in the CVR, although the information recorded there has been somewhat useful in the investigation of the incident.

Taking into account that no mechanical failure or system malfunction was detected on the aircraft after the incident, later that day when the aircraft was towed to a maintenance facility, or during troubleshooting procedure carried out a few days later, or during an actual taxi test carried out a few weeks later, it could be inferred that the incident had an operational nature.

The most probable scenario faced by the crew is described in the following subparagraphs in a sequential mode, with some discussion text added where necessary.

2.2.- Starting of the engines and pushback.

- Since the flight had some delay, and anxiety was increasing in the passenger cabin due to what was perceived as maintenance problems, the crew was probably speeding up a little bit the starting procedure of the engines.
- The crew was talking to the tower and had workload inside the cockpit. Therefore, they did not understand when the ground technician said “Rotating 3” and applied parking brake. This means that at that moment the brake system worked all right.
- At some point, the chief cabin crew advised that the passengers had seen fuel spilling. The CM-1 asked the ground technician whether he could see fuel falling from the wing.
- Then the ground technician asked for parking brakes, which were applied by the CM-1 without problem.
- In those confusing moments, after starting of engine 3, it is possible that the CM-3 activated the ground start ignition switch of engine 4 without waiting for the pilot in command to say “Start engine 4” as requested by the Operations Manual procedure and checklist. The ground technician saw the engine 4 rotating and said: “Rotating 4”.
- He was answered from the cockpit saying: “We have not started number 4 because there is an indication failure of EGT of engine 3”.

Therefore, engine 4 was cranked, but the CM-1 thought they had never tried to start that engine by moving the corresponding fuel lever. The CM-3 had activated the ignition switch, but maybe he did that as a routine action, in an automated mode, and when the problem with EGT 3 indication was evident, he was absorbed by the solution of that problem and forgot about the previous cranking of engine 4.

At that point, a relevant change of configuration had taken place without being noticed by any crew member: the electrical auxiliary hydraulic pump (ACP), devised precisely to provide braking pressure to ground operations when engine 4 is not running, had automatically come to OFF as a result of the cranking of engine 4.

If CM-3 had consciously noticed that the starting sequence of engine 4 had been initiated, and had remembered the engine start procedure, that specifically remarks: *"If engine 4 start is aborted, move again the switch of hydraulic system ACP to ON"*, maybe the chain of circumstances that led to the incident would have broken.

As parking brake was ON, and presumably the pedals depressed, the aircraft did not move and the remaining pressure was kept inside the accumulator.

2.3.- The decision to cancel the flight and the taxi back to the finger.

- Then, the CM-3 was busy looking up the manuals, while was being helped by the relief copilot. It was found that EGT 3 was a "no-go" item, and therefore, the CM-1 decided to return to the finger.
- At that moment, other factor contributed to the sequence of events, since the tow vehicle had already left. CM-1 decided to return by taxiing the aircraft with three engines, which implied applying some power to the engines and carefully checking the steering of the aircraft. Tow vehicles are in high demand in ground operations at Barajas Airport.
- An indication of the degree of anxiety or rush inside the cockpit is the fact that there is no evidence that the "After engine start" checklist was read before releasing the parking brake and starting the taxi back to the finger. If it had been read, the hydraulic systems would have been checked before initiating the taxi.
- Another indication is that, even though the crew knew that there were passengers standing, they decided to taxi without informing them or requesting that they occupy their seats. This decision was contrary to the normal procedures, that require that passengers are seated and with the seat belts fastened during taxi, takeoff and landing.
- Additionally, the CM-1 did not request that the visual docking guidance system was switched on, or the help of a signaler. He was confident that he would be able to park the aircraft using the ground marks.

- From that point on, it is possible that the CM-1 applied brakes and initially got some braking action due to the pressure retained by the accumulator. Tire marks were found on the apron, consistent with some braking of the wheels. However, this pressure was quickly wasted and, from that point on, there was no pressure at all available to the CM-1 or the CM-2. As it has been previously discussed, the pressure of the accumulator alone will probably not stop the aircraft unless the pilot is aware of the situation and applies carefully and continuously the brakes and then “traps” the pressure applying parking brake.
- After that loss of pressure happened, everything probably lasted very little time. It seems that the chief cabin attendant entered again the cockpit at those critical moments, and the crew members where distracted when concentration was needed the most to take a corrective action for the lack of braking action.
- The statements made by the CM-1 and CM-3 are not consistent with the hypothesis that is being exposed here. They positively remember seeing 3000 PSI in the accumulator indicator of the CM-2 and in the panel of CM-3. In addition, the CM-3 remembers seeing that the ACP was connected, and stated he saw the cover lifted. Both crew members do not remember seeing any caution or warning light during those moments.
- If that was the situation then the behavior of the aircraft would remain unexplained, because in the troubleshooting it was checked, with pressure gages installed in the wheels, that pressure reached every wheel when the proper cockpit procedures where applied.
- Both crew members later acknowledged that they could have taken corrective measures: switching the alternative hydraulic system 1 on (the CM-3) and switching the emergency hydraulic system 2 on (the CM-1). However, the close proximity of the finger left little time to react at those moments, and they did not have time to think of those corrective measures.
- There is no specific procedure in the Operations Manual for “emergency braking”, or specific refresher training for that kind of situation.
- The lack of braking action probably made the ground speed of the aircraft to increase a little bit, due to the thrust of the three operating engines. This would be the reason why, the speed increased to the point that ground observers noticed as abnormally high from the normal (reduced) speed at which the aircraft started moving, according to the recalls of the crew members.
- Under the circumstances described, and with the little time available to react, the CM-1 took the decision of crashing the aircraft into the finger, with the intend of stopping it and avoiding a more violent crash with other aircraft.

2.4.- Summary of factors that had an influence in the event

Therefore, there were several factors that influenced the incident:

- Previous maintenance tasks that did not correct the reported squawks. The EGT 3 indicator was changed. However, it seems the engine was not started after the change to check that the indication was correct, since the change of the gauge was accomplished with the aircraft parked at the finger. The refueling procedure ended with an appreciable amount of fuel dropping to the ground.
- The maintenance tasks had delayed the refueling of the aircraft, to the point that it was being performed while the passengers were boarding. The vision of maintenance people and firefighters working on the aircraft, and fuel spilling, made some passengers anxious.
- Little information was provided to the passengers on the maintenance status of the aircraft and the nature of the spillage of fuel.
- The failure to complete the after start checklist before initiating the taxi.
- The lack of a tow vehicle to tow the aircraft to the parking. The crew decided not to waste time waiting for another vehicle to come and decided to return immediately by their own means.
- The failure of the EGT 3 indication and other interruptions to the flight crew members, which introduced distractions that probably influenced their ability to make timely decisions and promptly take corrective measures.
- The influence of the fact that the relief flight engineer was not in the cockpit during the pushback and taxi maneuvers cannot be clearly assessed. There was another person occupying the place he used to have during takeoffs and landings. If he had been inside the cockpit, he could have helped the CM-3 to determine the cause of the loss of braking action of the system, based on his knowledge of the brake system and of the procedures to be followed by the flight engineer. However, this point remains undetermined, since the whole event happened in a short period of time.
-

2.5.- Discussion of possible safety recommendations

All those factors warrant the discussion of the issuance of several safety recommendations. In the first place, it would be beneficial to increase the training of flight crews of the operator in the area of emergency procedures related to the brake system of the B-747, to allow an automatic and quick answer in the event of a similar occurrence.

The problem of excess fuel falling from aircraft and causing concern to the passengers has happened other times in several aircraft models. It may be concluded that flight crews should receive additional training and procedures to cope with uprising passengers in the cabin, by means of providing

adequate information on the status of the aircraft and on the meaning of external signs the passengers could notice around the aircraft, specially regarding the spillage of fuel during taxi if this is a common situation in a given model of aircraft.

However, the possible behavior of the passengers inside a large commercial airplane is very difficult to anticipate, and the corrective measures to be applied will vary depending on the exact circumstances of a given event. Additionally, a possibility remains that giving too much technical information on the aircraft to the passengers could increase their degree of anxiety. Therefore, no clear safety recommendation that could be applied in practice has been identified at this point.

It would also be convenient to preclude people not needed for the operation of the aircraft, apart from relief crews, or not having any mission related to the operation of the aircraft, obviously apart from inspectors, instructors, etc. from occupying a seat in the cockpit during taxi, take off and landing, because in some emergency situations they could introduce additional disturbing factors with their sole presence inside the cockpit. This aspect is already requested by JAR-OPS and covered by the procedures of the Operator and, therefore, there is no need to issue a safety recommendation in that respect.

It was also considered necessary to recommend an improvement in the maintenance procedures of the operator, to be sure that line repairs of engine instrument indicators are adequately checked after completion. The fact is that the number 3 EGT indicator instrument was changed but the malfunction remained uncorrected and was evident to the crew upon the starting of engine 3.

The pilot in command is responsible of maintaining clearance with obstacles in the apron area. Although it is not considered to have direct influence in this incident, it seems that operations would be safer if there would be no option to taxi a large and heavy aircraft by its own means to a finger without any ground guidance. Therefore, it should be recommended to the operators to introduce that requirement in their procedures, and to the Airport authorities to introduce the procedure in the corresponding AIP. This latter action would require as a first step to clearly establish the boundaries of the maneuvering area and the apron area, and to assign to a given department the responsibility of each area.

2.5.1 Discussion of the influence of the brake system of the B-747

The brake system of the B-747 has a high degree of redundancy. However, under some circumstances, a deliberate human action is needed to avoid

leaving the aircraft without a brake pressure source apart from the accumulator whose main function is to keep the parking brake applied.

One of those circumstances is when the starting sequence of engine 4 is discontinued. Since the very beginning of the cranking of engine 4, the number 4 EDP or ADP start to pressurize the hydraulic system and the magnetically-held electrically driven hydraulic pump (ACP) control switch will release.

This situation is clearly highlighted in the Operations Manual used by the Operator. However, it seems that there could be a narrow "window" on the operation of the aircraft in which, if engine 4 is cranked but not started and a CM-3 action is not taken (connect again electrical pump ACP), the a/c could be left without brake pressure. The probability of this may be very low and the crew is supposed to be trained for that, but a chain of events (distractions of the crew due to angry passengers, other failures in the cockpit, etc.) could result in the aircraft or ground crews being put at hazard in busy, congested ground movement areas where, sometimes, relatively short time to react exists even at slow taxi speeds.

Some thoughts were devoted to try to devise a reasonable measure that could prevent future similar occurrences. The system has been basically the same on this aircraft during many years, and no specific problem related with the aspects covered in this report has been identified in the past, as far as it is known.

It was proposed to change the starting sequence of the engines during push back. So far, the Operations Manual of the Operator (see paragraph 1.6) states that the normal starting sequence of the engines is 4, 3, 2, and 1 except if the start is performed during pushback, in which case the recommended sequence is 1, 2, 3 and 4.

That means that when the aircraft is by its own, the first engine started (number 4) already provides normal hydraulic pressure to the brakes. If for any reason engine 4 start is discontinued, the aircraft does not have any engine running and it is not going to move by its own means in any case. Even if the ACP has switched OFF, parking brake will continue applied until ground help arrives.

However, if engines are started during pushback, the first engine started is number 1 and there is body landing gear steering available through ADP 1 to assist in turning the aircraft as it is being pushed by the tow vehicle. The aircraft is relying on the ACP to have available brake pressure until the end of the process, when engine 4 is started. In this case, if this engine is not finally started, the aircraft is still capable to taxi with the other three engines, which is what happened the day of the incident.

It seems that starting engine 4 in the first place during pushback too, as it is done in the other case, would eliminate the problem of taxiing with engine 4 not running and ACP inadvertently left in OFF position, because if starting of engine 4 is discontinued there is no other engine to taxi by its own means.

However, in this case the ADP 1 should be running on APU pneumatic power alone to have body landing gear steering available, and this could impose additional loads to the pneumatic system until the end of the process, in which engine 1 would be started.

It is not clear at this point whether the change in the sequence would increase the safety of the process without adding any potential source of other problems to the operation of the aircraft.

As stated in paragraph 1.6, the Manufacturer's Generic Operations Manual does not recommend any specific engine starting sequence in any situation (whether or not in pushback). Therefore, it is considered worthwhile to recommend that the specialists of the Manufacturer and the Operator jointly study the issue and, after a hazard analysis, reach a conclusion regarding the need, if any, of recommending a given engine starting sequence during pushback.

3.- CONCLUSIONS

3.1.- Evidences

The flight crew was qualified for the flight and had valid licenses.

Inspections and checks performed on the aircraft after the incident did not show any malfunction of the hydraulic and brakes systems.

The cockpit was occupied by the pilot in command, the copilot, the flight engineer, a relief copilot, and a passenger during the pushback and taxi maneuvers.

The crew requested the ATC, and was authorized, to return to the finger taxiing.

The switch of the alternate hydraulic system number 1 and the switch of the emergency hydraulic system number 2 were not moved to connect those systems during the period of time in which the aircraft started the taxi and the moment it impacted with the finger.

A witness on the ground stated that he saw the engine 4 rotating, as at the beginning of the starting sequence of this engine.

There were several passengers in the cabin that complained and stated they were refusing to fly during the pushback maneuver and that were standing when the aircraft initiated the taxi back to the finger.

3.2.- Causes

It is considered that the probable cause of this incident was the fact that the electrically driven hydraulic pump (ACP) was not manually connected again after its switch automatically released as a result of the initiation of the starting process of engine number 4 and once that starting process had not been completed.

Contributing factors to this incident were:

- The behavior of some passengers, that were complaining, refusing to fly and standing in the passenger cabin and that made the chief cabin attendant to enter at least twice the cockpit to inform the pilot in command.

- The failure to complete the “after start” checklist detailed in the Operations Manual of the operator.

- The failure to connect the alternative or emergency hydraulic systems when the brake failure was noticed.

4.-SAFETY RECOMMENDATIONS

REC 03/03. It is recommended to Iberia that the training provided to flight crews of B-747 devotes more time to the review of the abnormal and emergency procedures related to the brake system, and specifically remarks the fact that if starting of engine 4 is discontinued, the electrically driven hydraulic pump (ACP) must be connected again by the flight engineer.

REC 04/03. It is recommended to Iberia that their line maintenance procedures are reviewed to ensure that there is a means to check the adequate completion of engine instrument indicators on line repair or maintenance.

REC 05/03. It is recommended to the Direccion General of “Aeropuertos Españoles y Navegación Aérea” (AENA) that clearly establishes the boundaries between the maneuvering and the apron areas of Madrid-Barajas Airport, and that responsibility for the safe movements of aircraft, vehicles and people within the apron is assigned to an identified department.

REC 06/03. It is recommended to the Direccion General of “Aeropuertos Españoles y Navegación Aérea” (AENA) that requirements and procedures are introduced in the AIP to request that ground guidance (in the form of either human signalers or visual docking guidance systems) is mandatory before and during the taxi maneuver of an aircraft towards a finger in Madrid-Barajas Airport.

REC 12/03. It is recommended that Iberia, jointly with the manufacturer of the aircraft, The Boeing Company, reviews the hazards associated to the possible engine starting sequences of the B-747 to determine the most suitable process in every circumstance. The Operations Manual of Iberia should be amended, if needed, to include that determination.

5.- APPENDICES

Appendix A. Photographs.

Appendix B. Drawing of the final position of the aircraft.

APPENDIX A

PHOTOGRAPHS


14 18:43


ATH
14 18:12

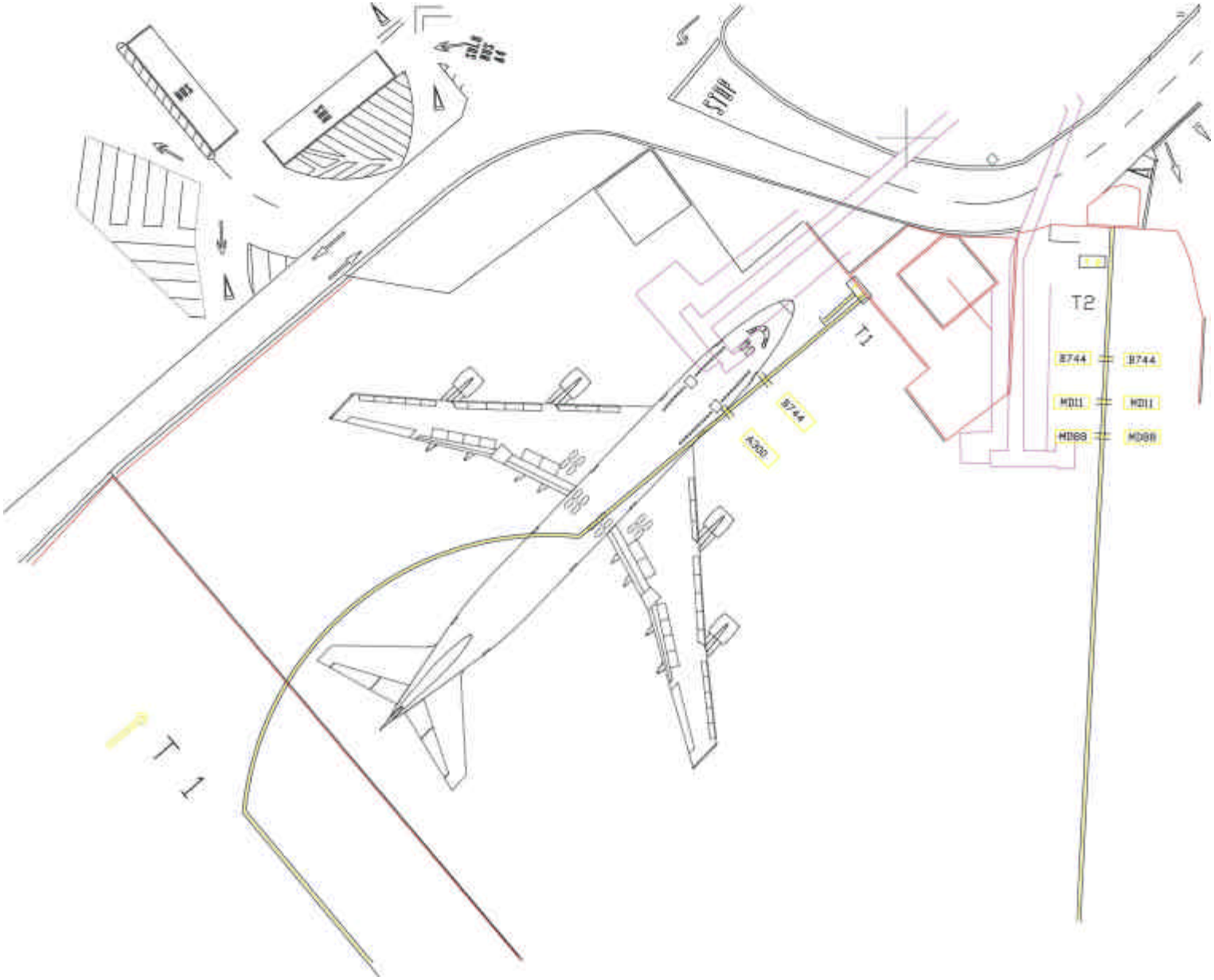

LUIS DE GONGORA
14 18:12
ATH


14 18:43


14 18:52

APPENDIX B

DRAWING OF THE FINAL POSITION OF THE AIRCRAFT


T1
T2
B744
MD11
MD88
A300